Overview of ADOT's Quiet Pavement Pilot Program (QPPP)

EEG Brownbag

April 2006

ADOT's Experience With Rubberized Asphalt Products

- Pavement research began in 1973
- First non-experimental overlay of asphaltic rubber friction course (ARFC) placed in 1985 on Interstate-17
- Precursor of today's ARFC mix design first placed in 1988 on Interstate-19

Arizona Highways with Asphaltic Rubber

ADOT Maintains Over 6400 Roadway Miles of Highway

More Than 3200 Roadway Miles Have A Rubberized Asphalt Product

Construction Year

1988	1994	2000
1989	1995	2001
1990	1996	2002
1991	1997	2003
1992	1998	2004
1993	1999	2005

0 20 40 60 80 100

Miles

ADOT EEG

ADOT's Experience With Rubberized Asphalt Products

- Pavement research began in 1973
- First non-experimental overlay of asphaltic rubber friction course (ARFC) placed in 1985 on Interstate-17
- Precursor of today's ARFC mix design first placed in 1988 on Interstate-19
- ADOT began research on the noise reduction benefits of ARFC in 1995
- ADOT completed a noise study in January 2002 on a test section of SR 101 overlaid with ARFC
- ADOT initiated the QPPP in April 2003, in accordance with an agreement between FHWA and ADOT

Purpose of the QPPP Research Data

The research data must answer two basic questions:

#1 Does an ARFC overlay reduce noise levels by at least 4 decibels in neighborhoods adjacent to freeways?

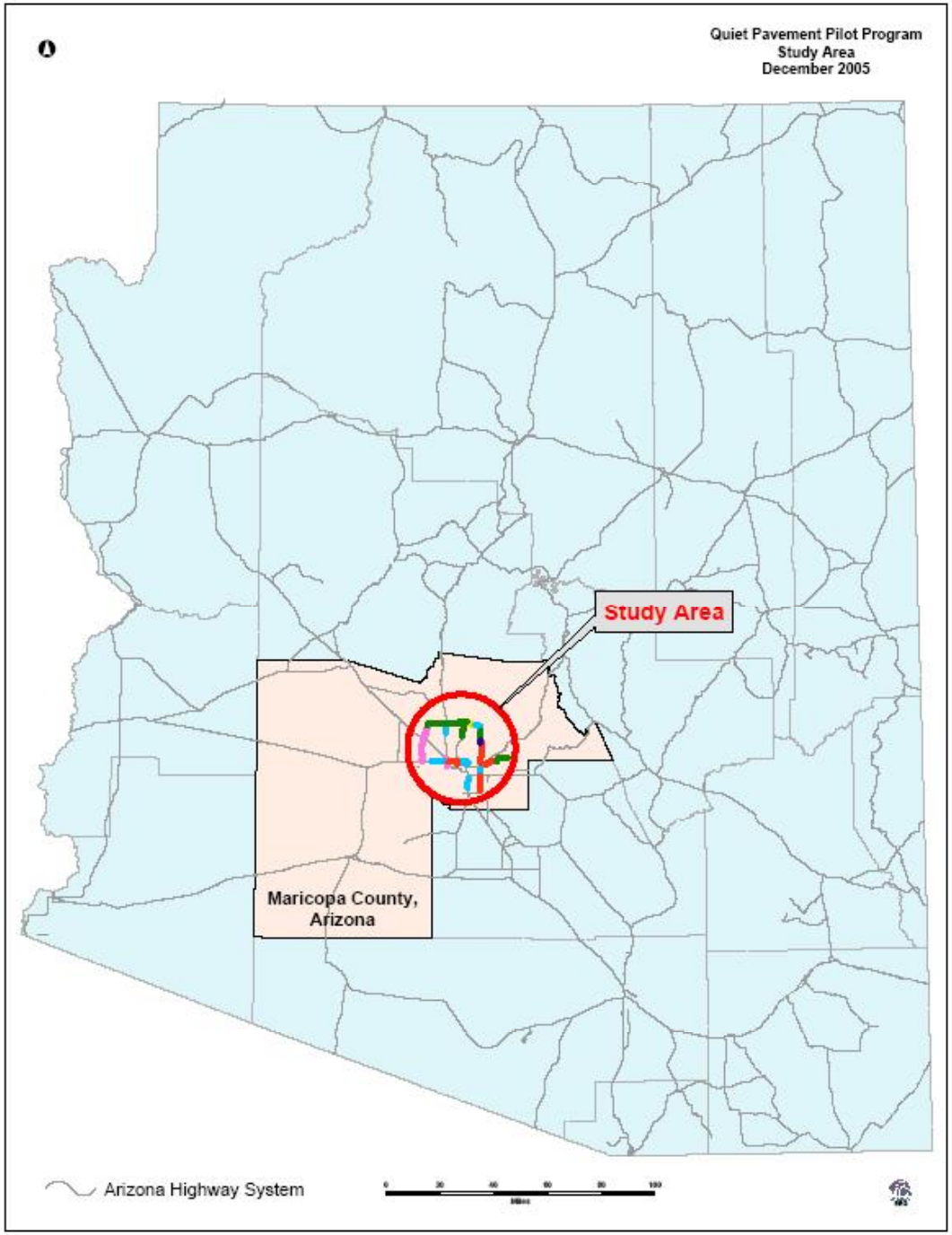
#2 Is the reduction sustained over the life of overlay?

Conduct pre- and post-overlay monitoring at three types of study sites (Question 1)

Collect post-overlay noise readings periodically for up to ten years (Question 2)

Determine noise level reductions

Present findings in progress reports


Quiet Pavement Pilot Program
Study Area
December 2005
Study Area
Maricopa County,
Arizona
Arizona Highway System

Project Area

The QPPP research involves 115 miles (Phases 1 to V) of the Regional Freeway System in Maricopa County, Arizona

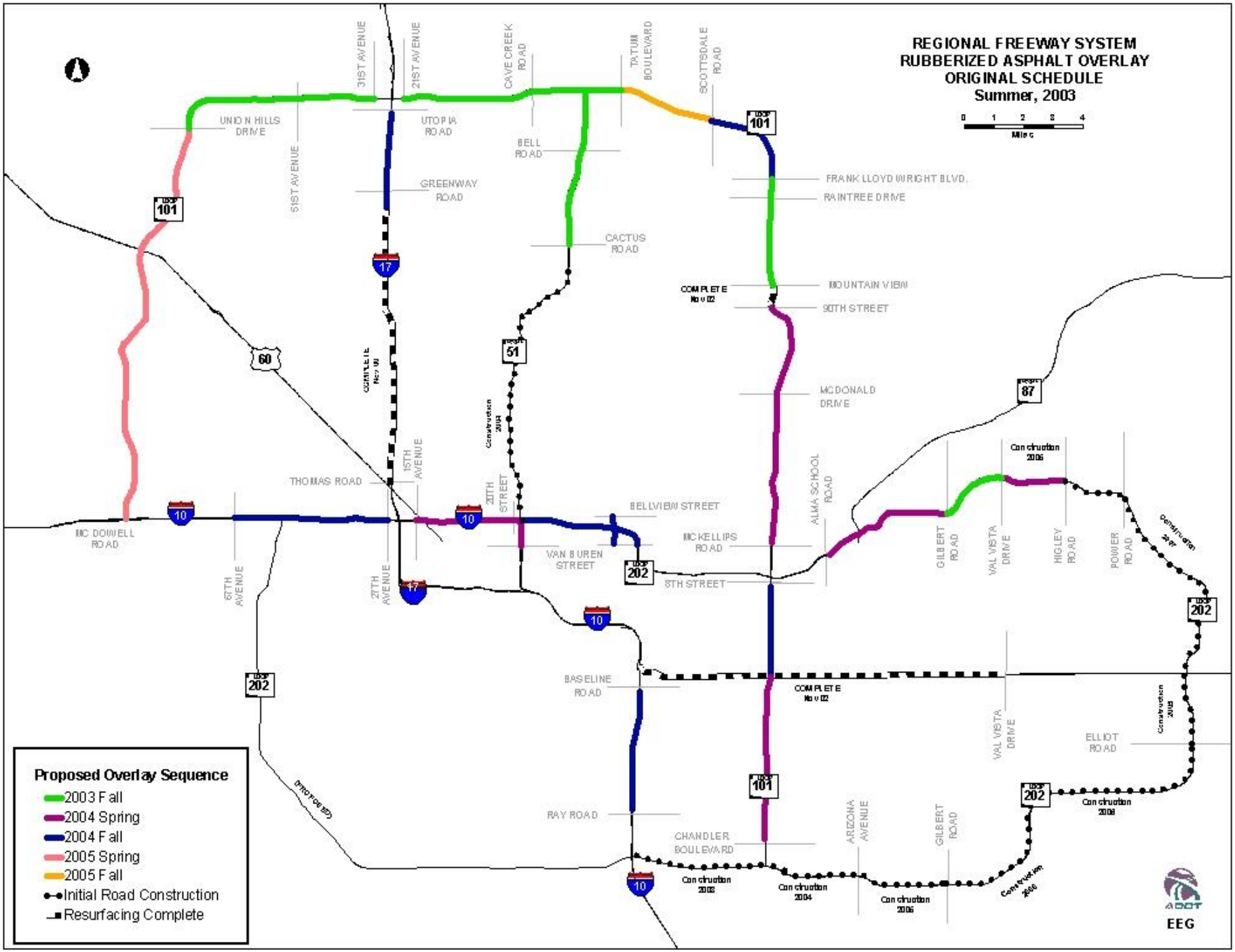
The Maricopa Association of Governments (MAG) is the metropolitan planning organization (MPO)

The project area includes Phoenix, Scottsdale, Mesa, Glendale, Tempe, Chandler (members of MAG)

ADOT placed ARFC overlay on 18 segments during Construction Phases I through V

ADOT will place ARFC overlay on additional segments during Construction Phases VI through X

ARFC will overlay the entire Maricopa Regional Freeway System when Phase X is complete


REGIONAL FREEWAY SYSTEM
RUBBERIZED ASPHALT OVERLAY
ORIGINAL SCHEDULE
Summer, 2003
0 1 2 3 4
Miles
31ST AVENUE
21ST AVENUE
CAVE CREEK ROAD
TATUM BOULEVARD
SCOTTSDALE ROAD
UNION HILLS DRIVE
UTOPIA ROAD
BELL ROAD
51ST AVENUE
GREENWAY ROAD
FRANK LLOYD WRIGHT BLVD.
RAINTREE DRIVE
CACTUS ROAD
MOUNTAIN VIEW
COMPLETE Nov 02
90TH STREET
MCDONALD DRIVE
Construction 2004
19TH AVENUE
THOMAS ROAD
20TH STREET
BELLVIEW STREET
ALMA SCHOOL ROAD
Construction 2006
MC DOWELL ROAD
MCKELLIPS ROAD
VAN BUREN STREET
GILBERT ROAD
VAL VISTA DRIVE
HIGLEY ROAD
POWER ROAD
Construction 2007
8TH STREET
27TH AVENUE
67TH AVENUE
BASELINE ROAD
COMPLETE Nov 02
ELLIOT ROAD
Construction 2008
RAY ROAD
CHANDLER BOULEVARD
ARIZONA AVENUE
Construction 2008
Construction 2004
Construction 2006
Construction 2006
Proposed Overlay Sequence
2003 Fall
2004 Spring
2004 Fall
2005 Spring
2005 Fall
Initial Road Construction
Resurfacing Complete
ADOT
EEG

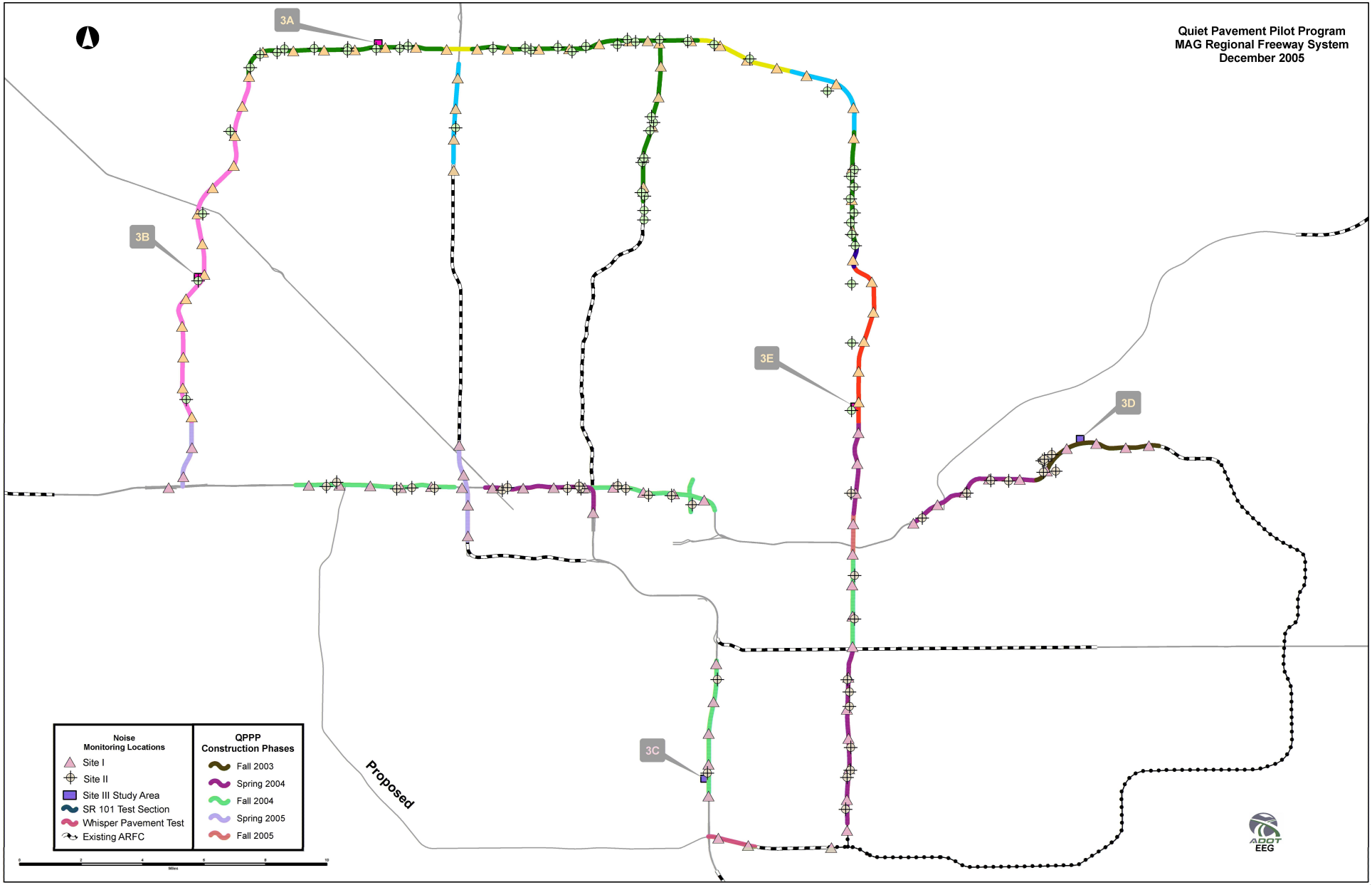
Types of Noise Measurements

Site 1: Noise reduction at the tire/pavement interface (source measurements)

Site 2: Noise reduction in residential neighborhoods (wayside measurements)

Site 3: Noise reduction at research quality sites (wayside measurements)

Noise Measurement Positions



Noise Measurement Methodologies

Site 1

Source Measurement

(Close Proximity Method)

Site 1

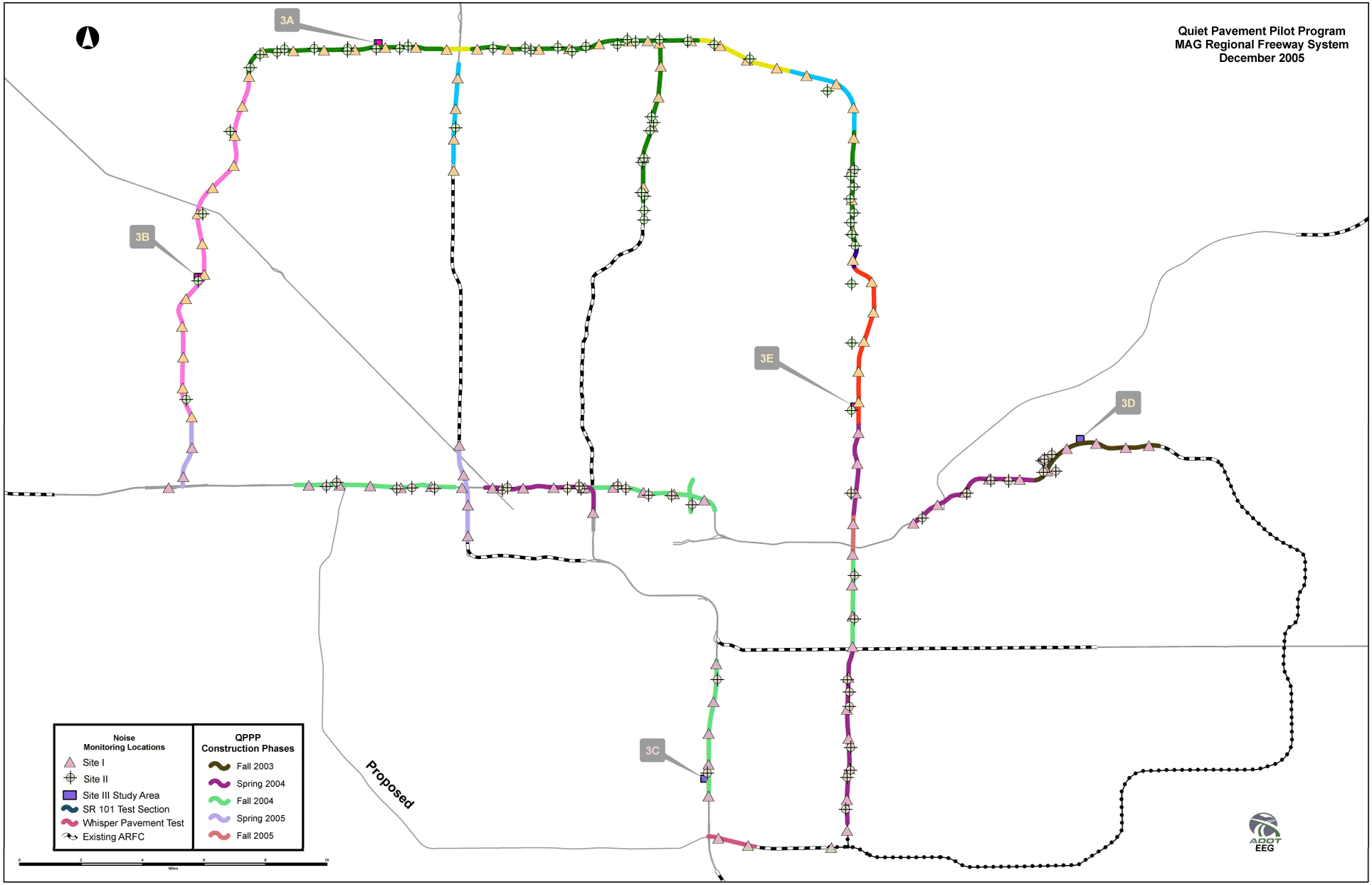
Source Measurement

(Sound Intensity Method)

Site 2 and Site 3

Wayside Measurement

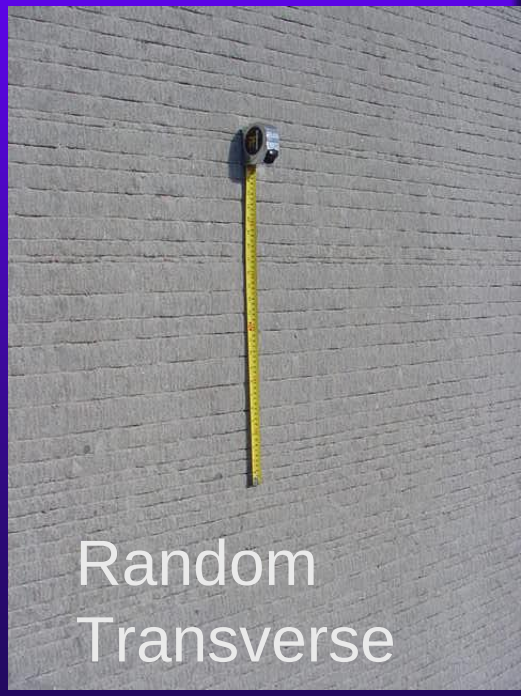
Noise Measurement Positions



Site 1 Pre-Overlay Conditions: Concrete Textures

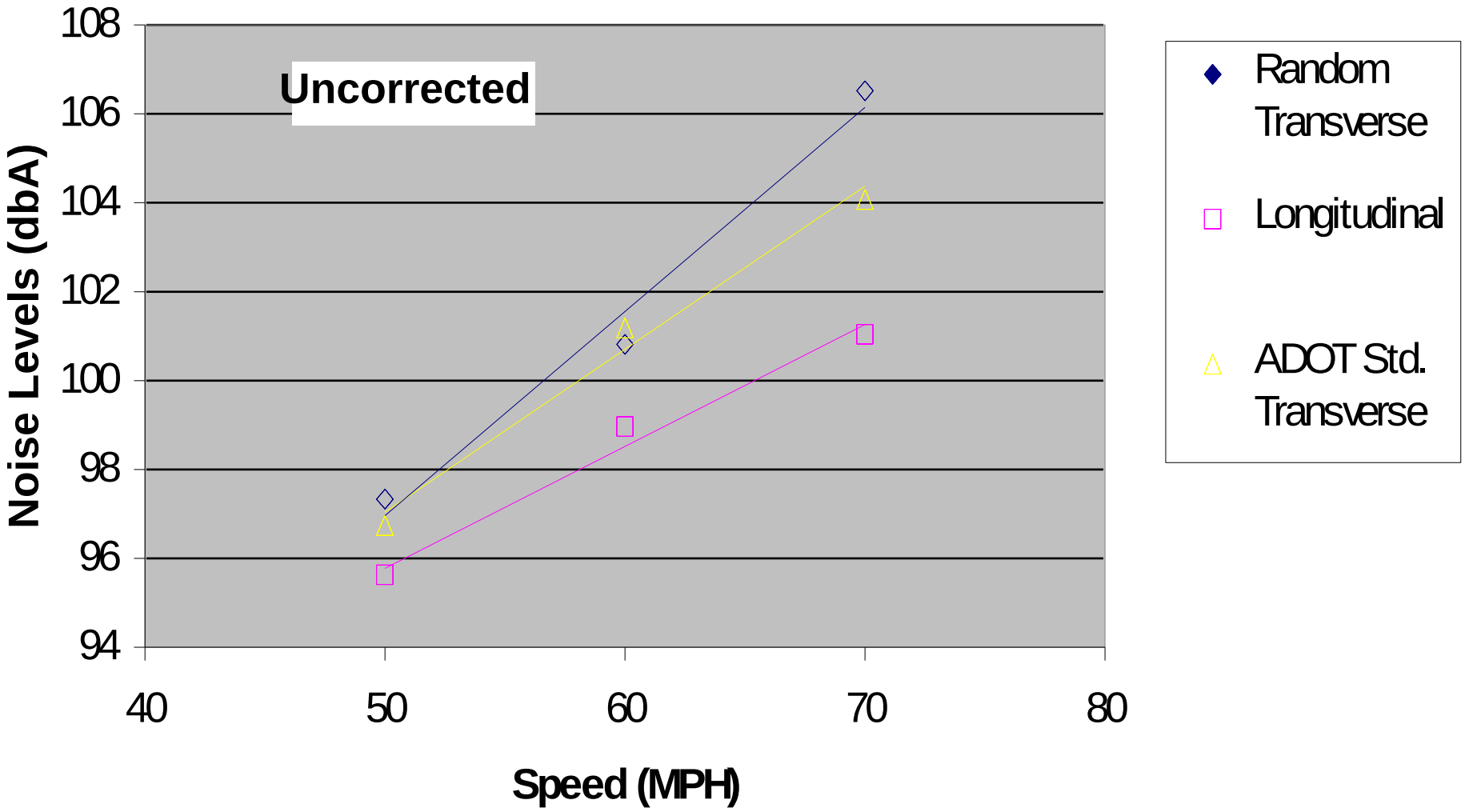
Longitudinal

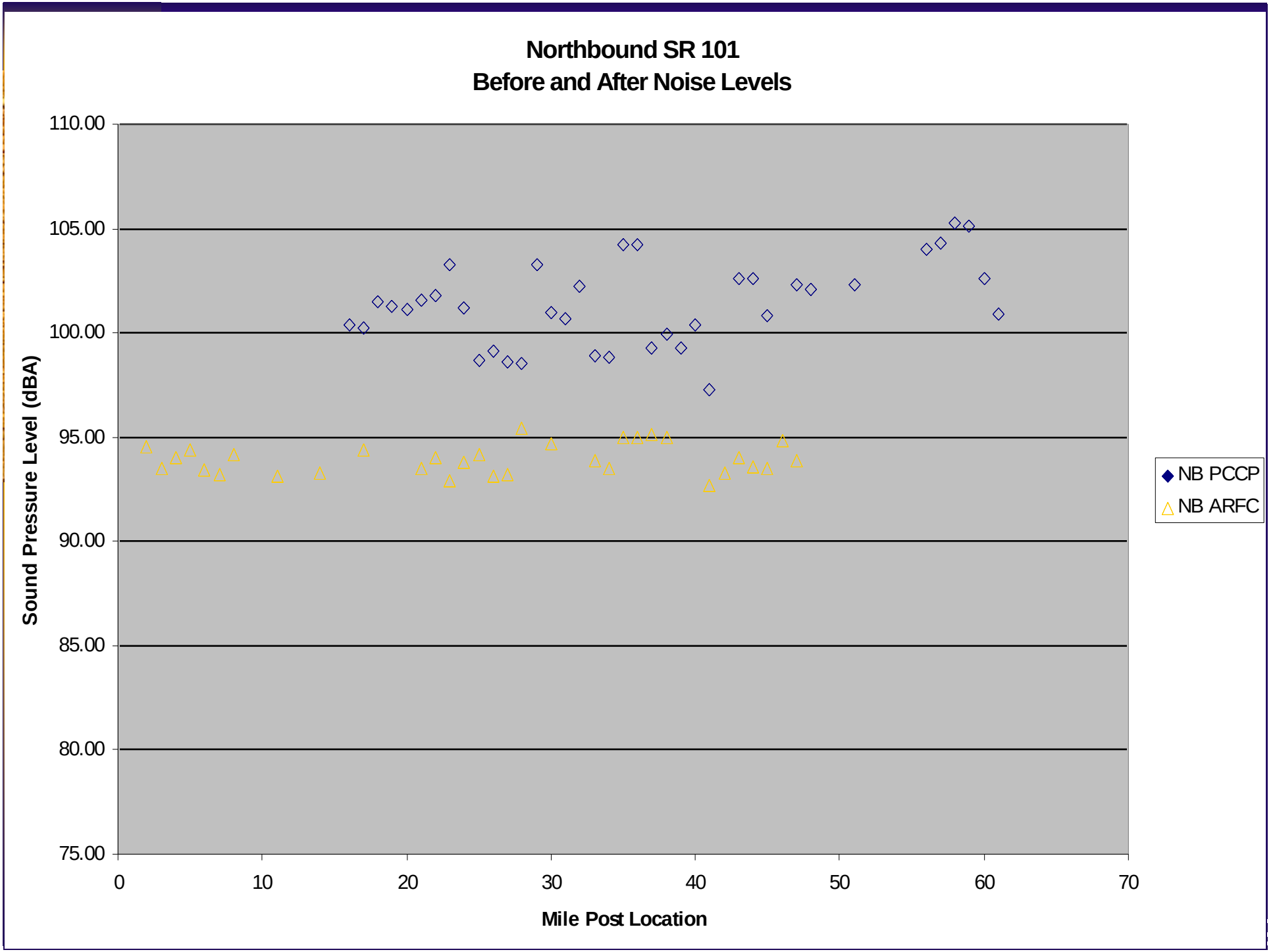
Uniform Transverse

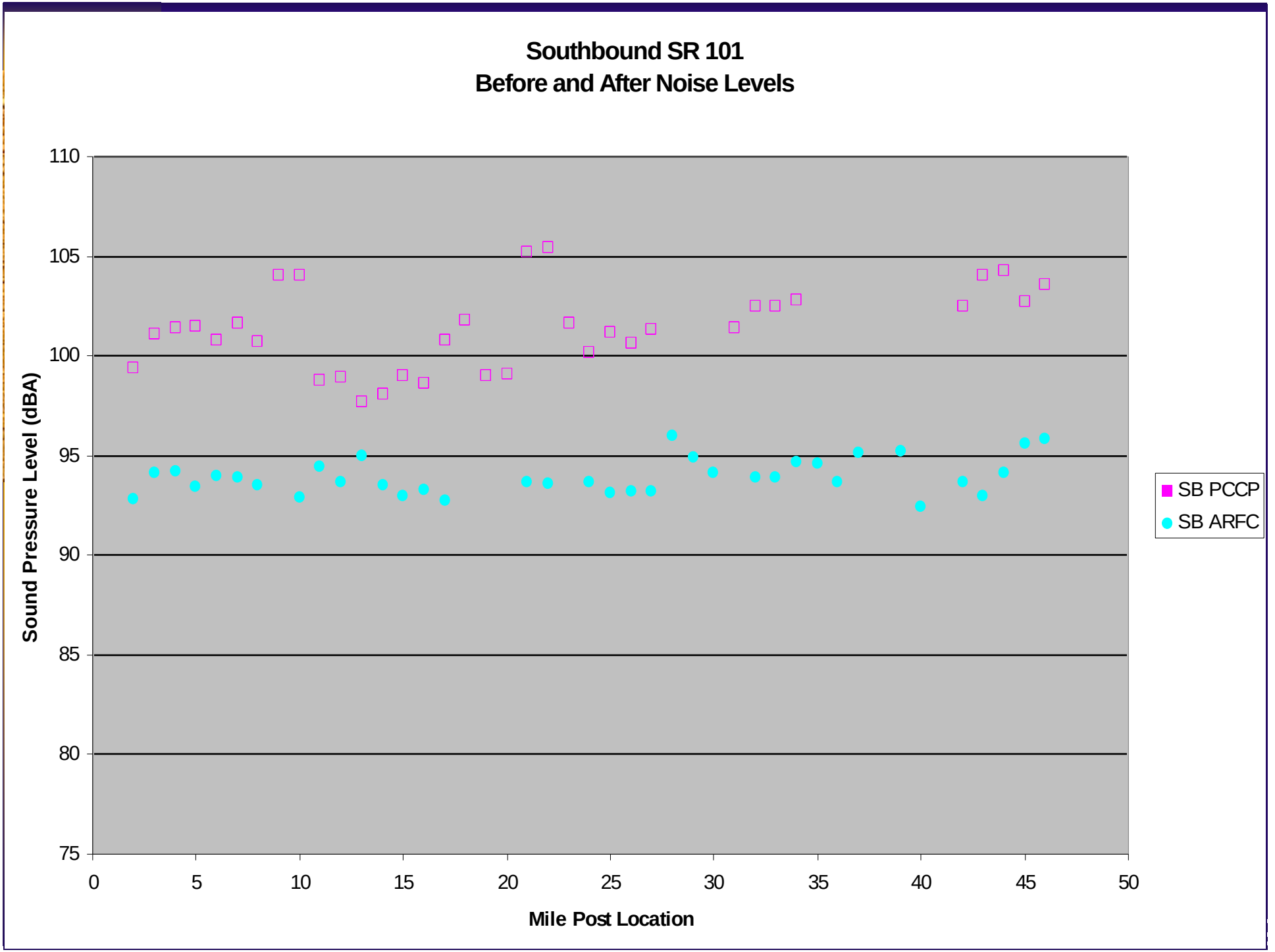


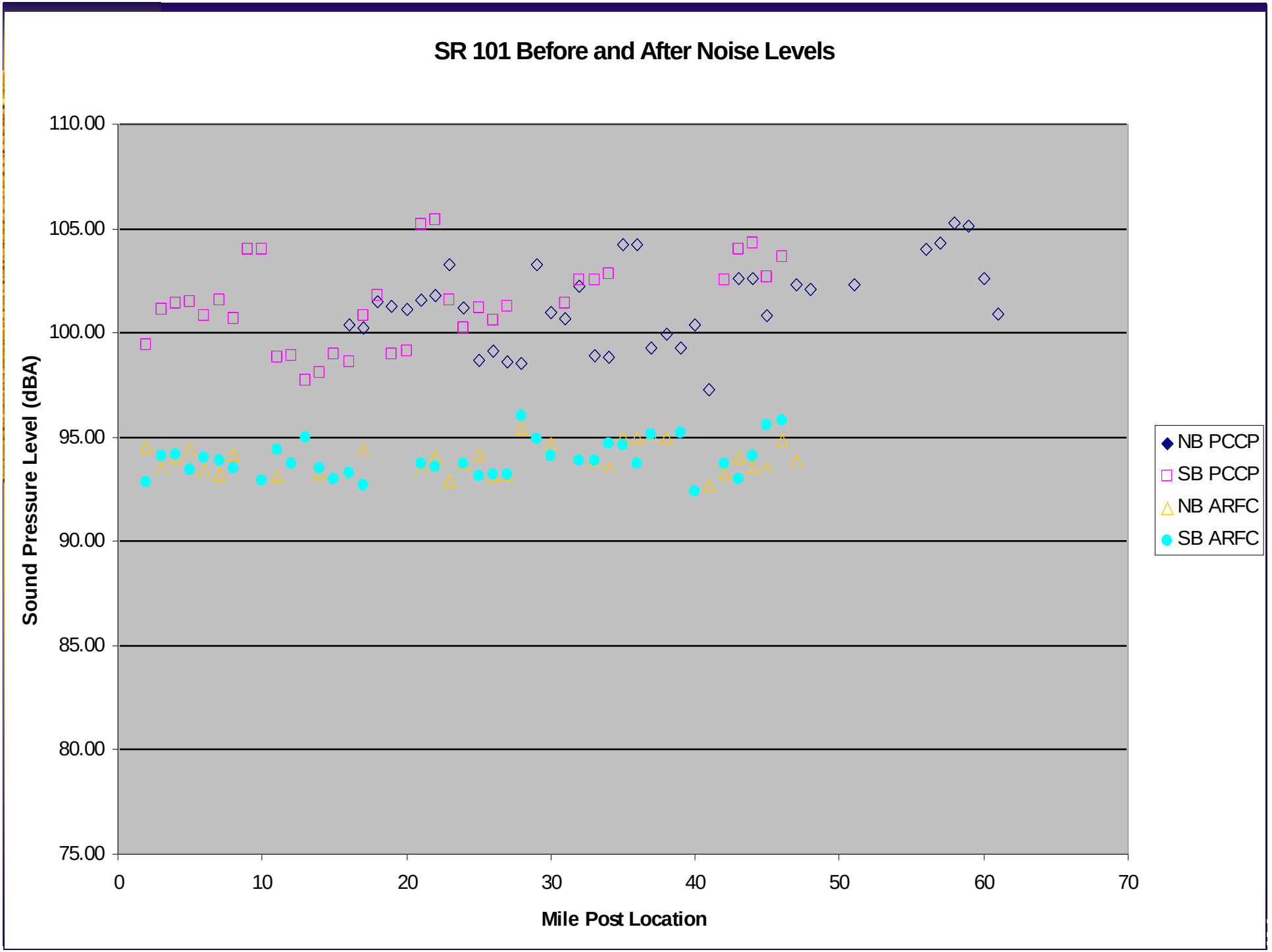
Random Transverse

Uncorected CPX dBA Levels as a Function of Texture Type and Speed




Northbound SR 101
Before and After Noise Levels
Sound Pressure Level (dBA)
110.00
105.00
100.00
95.00
90.00
85.00
80.00
75.00
0
10
20
30
40
50
60
70
Mile Post Location
NB PCCP
NB ARFC


Southbound SR 101
Before and After Noise Levels
Sound Pressure Level (dBA)
110
105
100
95
90
85
80
75
0
5
10
15
20
25
30
35
40
45
50
Mile Post Location
SB PCCP
SB ARFC

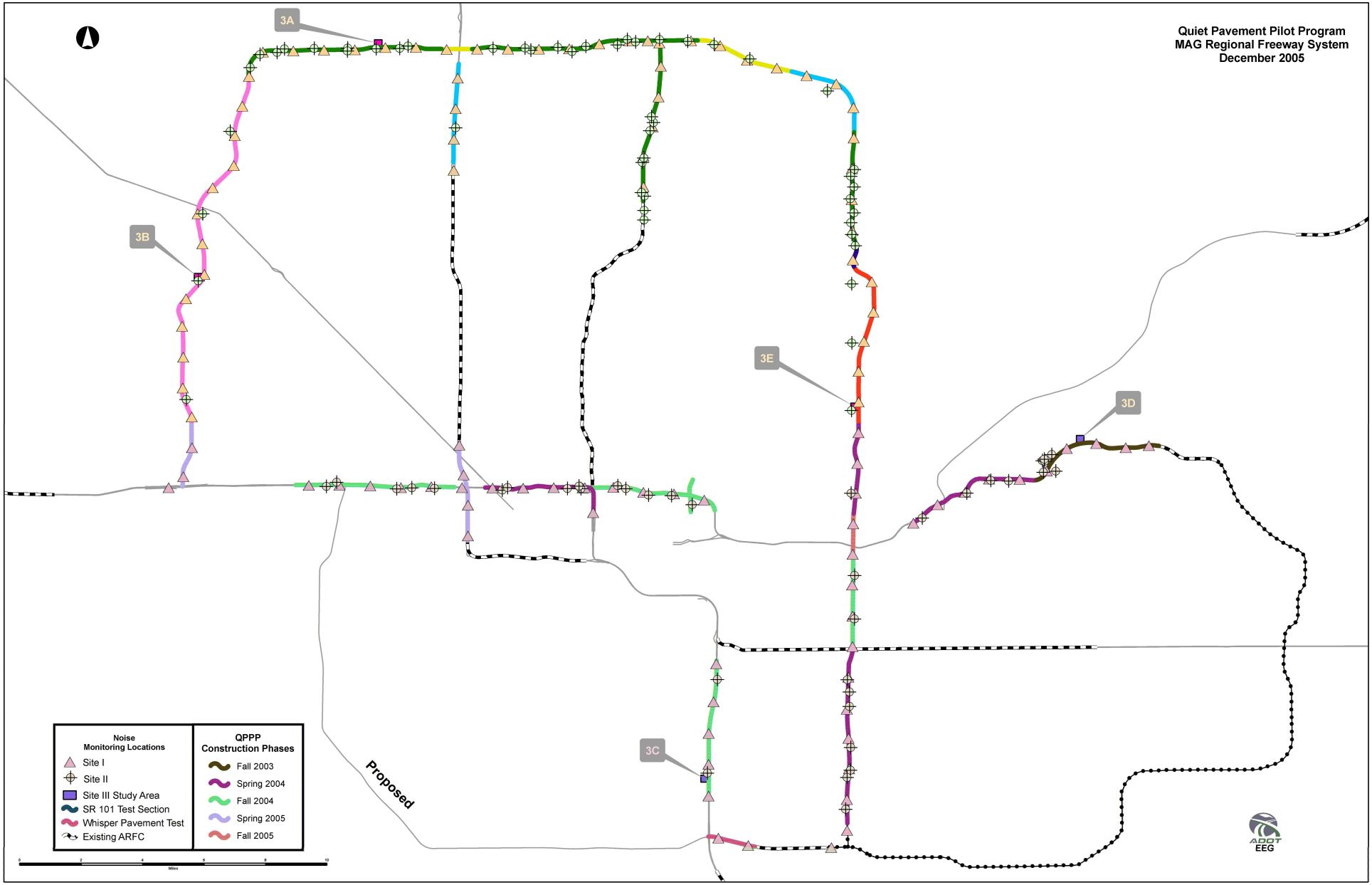

SR 101 Before and After Noise Levels
Sound Pressure Level (dBA)
110.00
105.00
100.00
95.00
90.00
85.00
80.00
75.00
0
10
20
30
40
50
60
70
Mile Post Location
NB PCCP
SB PCCP
NB ARFC
SB ARFC

Initial Noise Reductions

Site 1

Range of Noise Reductions	-4.1 dBA to -13.2 dBA
Average Noise Reduction	8.3 dBA

Noise Measurement Positions



Site 2 Positions

Represent residential subdivisions

Ability to conduct follow-up noise measurements

Real-world conditions:

- With and without intervening noise barriers
- Elevated, depressed, and at-grade segments
- Proximity to non-ARFC arterial roads
- Variations in adjacent topography

Site 2 Measurement Criteria

Continuously monitor each segment for 24 hours

Measure each Site 2 position during peak traffic noise conditions

Complete three consistent 20-minute measurements at each Site 2 position

Document weather conditions during measurement

Determine traffic mix and volumes using video

Measure vehicle speeds using radar

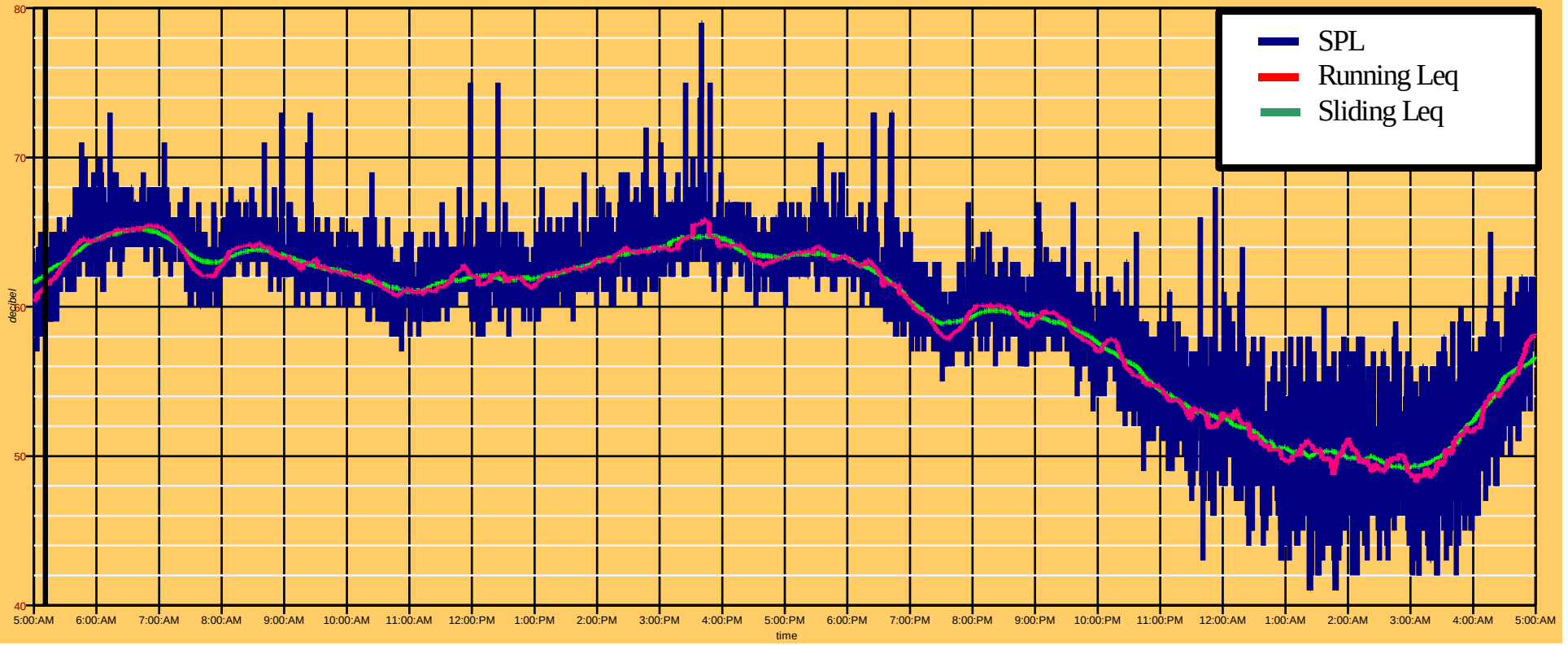
24 Hour Reading in DNA Software

ARFC Overlay Pilot Program

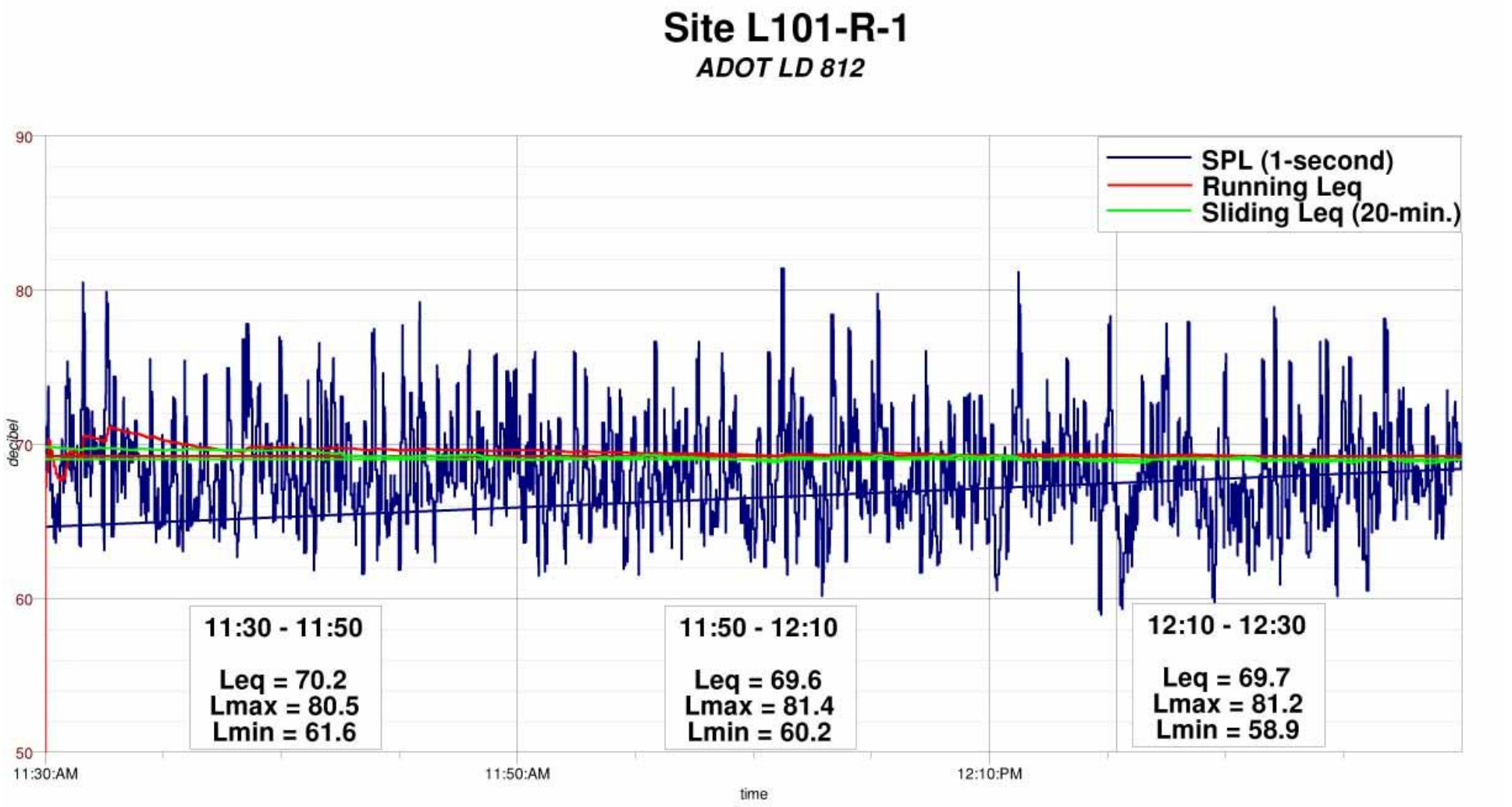
24-Hour Noise Monitoring

September 23, 2003 to September 24, 2003

L101 Pima Freeway - At Cholla Street



1 Hour Reading in DNA Software



Data Analysis/Reduction

Vehicle equivalents used to compare pre- and post-overlay measurements

Equivalent Vehicles Based on TNM REMELs**			
	NUMBER OF EQUIVALENT VEHICLES		
Speed km/h (mph)	1 Heavy Truck =	1 medium truck =	1 Automobile =
56 (35)	19.1	7.1	1
64 (40)	15.1	5.8	1
72 (45)	12.9	5.0	1
80 (50)	11.5	4.5	1
88.5 (55)	10.4	4.1	1
97 (60)	9.6	3.7	1
105 (65)	8.9	3.5	1
113 (70)	8.3	3.2	1

** Based on FHWA Traffic Noise Model (TNM) Reference Energy Mean Emission Levels and vehicle definitions in FHWA-PD-96-008, DOT-VNTSC-FHWA-96-2.

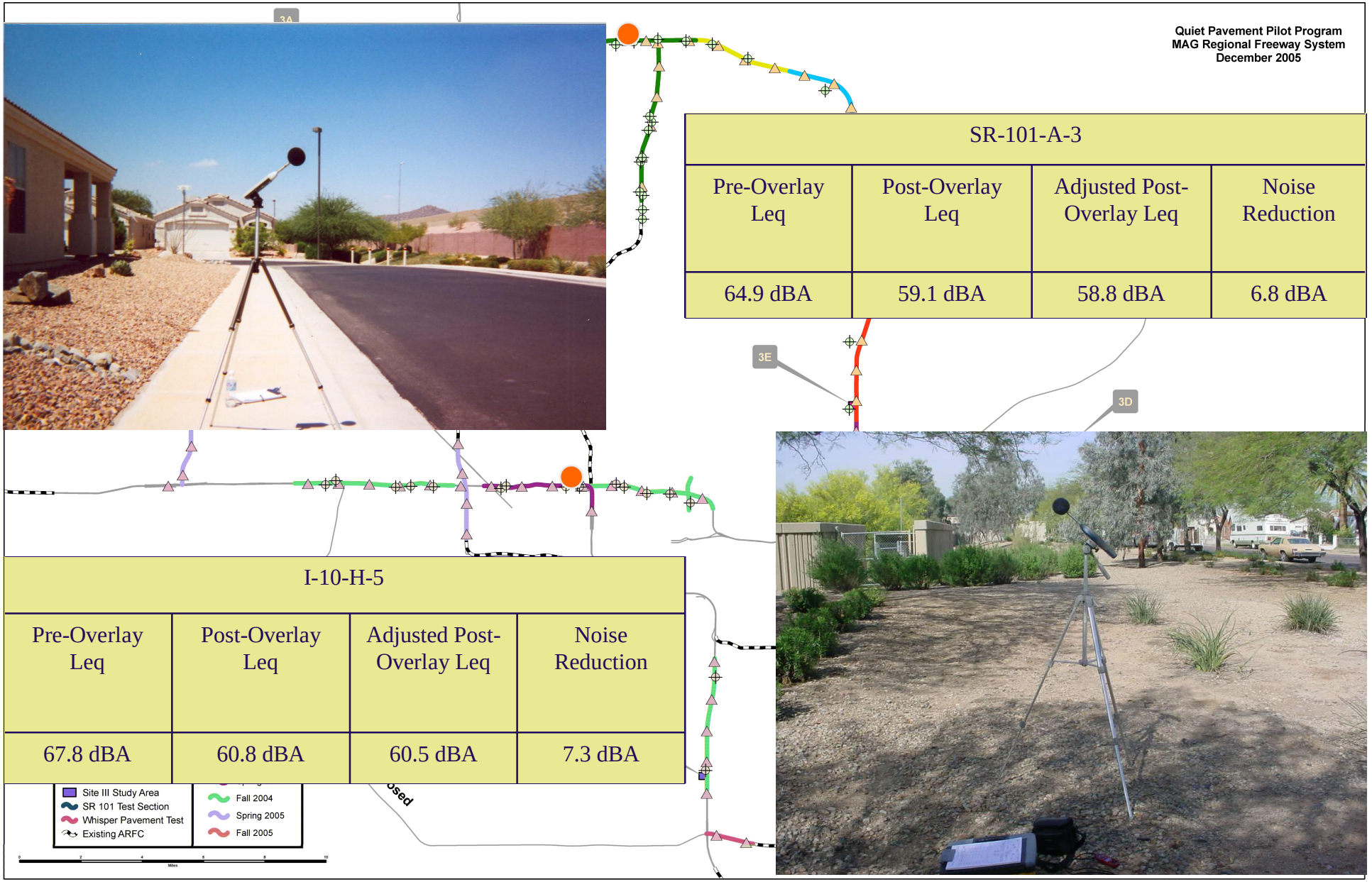
Sample Calculation Vehicle Equivalents

Site Name:	SR101-A-1									
Before Noise Level	Leq (1)	74.6								
After Noise Level	Leq (2)	69.8								
								65 mph		
Before		EB		WB		Total		Equiv		V_E
(Measurement 1)	Cars	6652	+		=	6652	*	1	=	6652
	MT	241	+		=	241	*	3.5	=	843.5
	HT	166	+		=	166	*	8.9	=	1477.4
								Total V_E (1)	=	8973
								65 mph		
After		EB		WB		Total		Equiv		V_E
(Measurement 2)	Cars	6944	+		=	6944	*	1	=	6944
	MT	227	+		=	241	*	3.5	=	794.5
	HT	253	+		=	166	*	8.9	=	2251.7
								Total V_E (2)	=	9990
Correction										
Formulas:										
$C=10Log_{10}[V_E(1)/V_E(2)]$				Leq(2N)=Leq (2) + c						
c = -0.5				Leq (2N) = 69.3						
Comparison										
Before [Leq(1)] = 74.6										
After [Leq (2N) = 69.3										
Difference =	5.3									
After noise level at SR101-A-1 is 5.3 decibels lower than "Before" Noise Level.										

Examples of Site 2 Measurement Positions

Quiet Pavement Pilot Program
MAG Regional Freeway System
December 2005

SR-101-A-3			
Pre-Overlay Leq	Post-Overlay Leq	Adjusted Post-Overlay Leq	Noise Reduction
64.9 dBA	59.1 dBA	58.8 dBA	6.8 dBA



I-10-H-5			
Pre-Overlay Leq	Post-Overlay Leq	Adjusted Post-Overlay Leq	Noise Reduction
67.8 dBA	60.8 dBA	60.5 dBA	7.3 dBA

Initial Noise Reductions

Site 2

Range of Noise Reductions	+1.3 dBA to –12.3 dBA
Average Noise Reduction	5.3 dBA

Site 2 Findings to Date

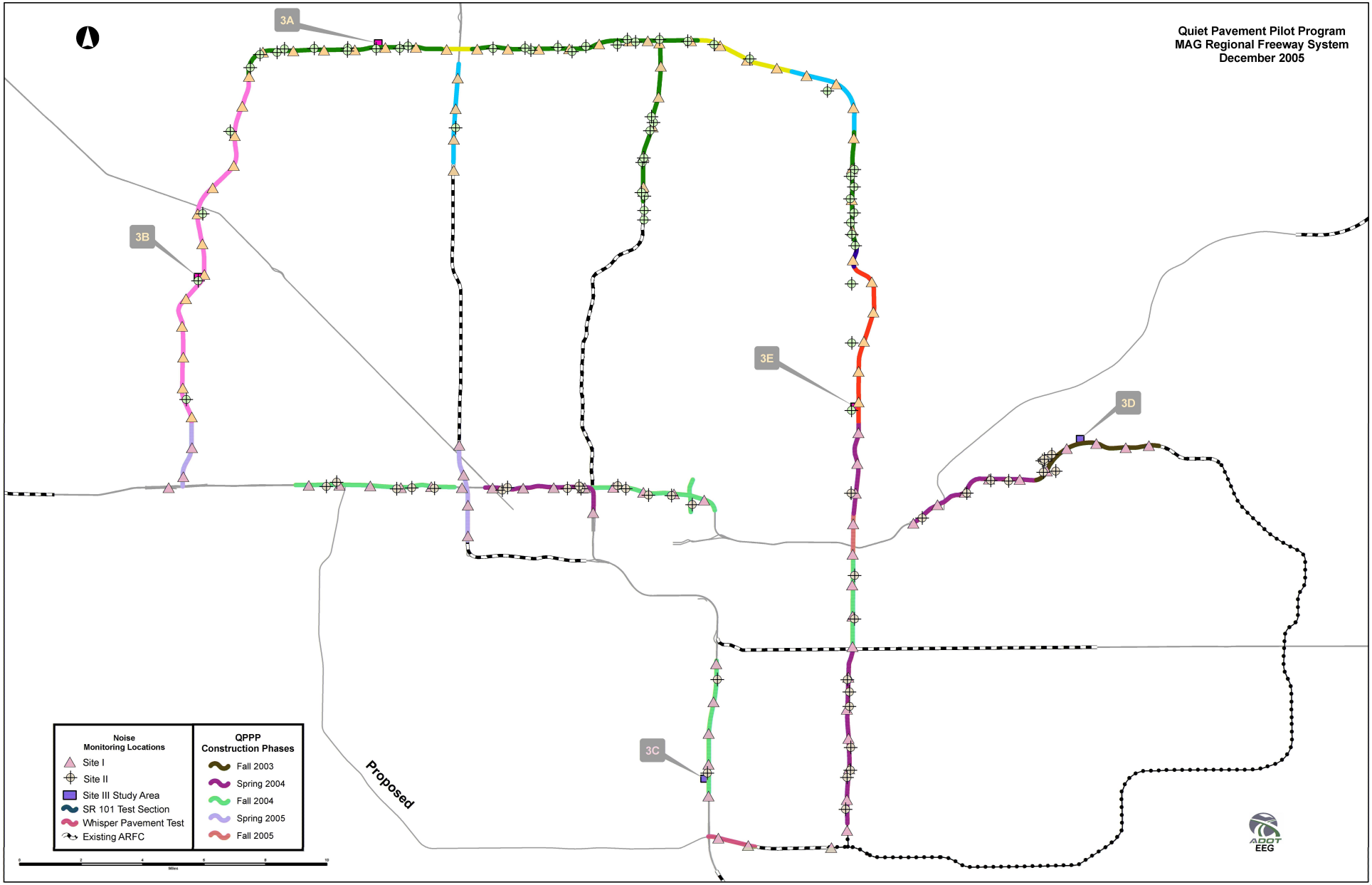
Average noise reduction exceeds 4 dBA in adjacent areas

ARFC overlay extends noise reduction benefits to more receivers and affects larger areas, when compared to noise barriers

Initial public response is favorable

Phase #	Total Miles	Number of Positions	Average Reduction
Phase 1	37	44	4.8 dBA
Phase 2	29	25	5.9 dBA
Phase 3	25	12	5.0 dBA
Phase 4	19	5	3.7 dBA
Phase 5	5	2	9.6 dBA
Total	**115**	**88**	**5.3 dBA**

Noise Measurement Positions



Site 3D


Noise
Monitoring Locations
Site I
Site 2
SR 101 Test Section
Whisper Pavement Test
Point_ge
0
0.05
0.1
0.15
0.2
0.25
Miles
Quiet Pavement Pilot Program
Site 3D
May 2006
ADOT
EEG

Site 3D

Site 3A

Position	Pre-Overlay (Averaged)			Post-Overlay (Averaged)			Noise Reduction
	Modeled	Measured	Difference	Modeled	Measured	Difference	
50ft/12ft	79.8 dBA	82.5 dBA	-2.7 dBA	79.5 dBA	74.8 dBA	4.7 dBA	-7.4 dBA
50ft/5ft	79.9 dBA	82.3 dBA	-2.4 dBA	79.5 dBA	75.1 dBA	4.4 dBA	-6.8 dBA
100ft/5ft	77.3 dBA	76.7 dBA	+0.8 dBA	77.2 dBA	71.3 dBA	5.9 dBA	-5.1 dBA
175ft/5ft	--	--	--	74.6 dBA	66.9 dBA	--	--

Site 3B

Position	Pre-Overlay (Averaged)			Post-Overlay (Averaged)			Noise Reduction
	Modeled	Measured	Difference	Modeled	Measured	Difference	
50ft/5ft	In progress	82.9 dBA	--	In progress	74.1 dBA	--	-8.7 dBA
95ft/5ft	In progress	76.9 dBA	--	In progress	70.2 dBA	--	-6.7 dBA
246ft/5ft	In progress	70.3 dBA	--	In progress	62.0 dBA	--	-8.2 dBA
Class (A)	In progress	47.1 dBA	--	In progress	46.6 dBA	--	-0.5 dBA
Class (B)	In progress	40.0 dBA	--	In progress	39.8 dBA	--	-0.3 dBA
Class (B)	In progress	52.9 dBA	--	In progress	51.1 dBA	--	-1.8 dBA
Amphitheater	In progress	68.1 dBA	--	In progress	63.7 dBA	--	-4.4 dBA

Site3C

Position	Pre-Overlay (Averaged)			Post-Overlay (Averaged)			Noise Reduction
	Modeled	Measured	Difference	Modeled	Measured	Difference	
50ft/9.5ft	In progress	82.9 dBA	--	In progress	75.2 dBA	--	-7.7 dBA
141ft/5ft	In progress	72.4 dBA	--	In progress	66.9 dBA	--	-5.6 dBA

Site 3D

Position	Pre-Overlay (Averaged)			Post-Overlay (Averaged)			Noise Reduction
	Modeled	Measured	Difference	Modeled	Measured	Difference	
50ft/12ft	75.1 dBA	84.3 dBA	-9.2 dBA	74.0 dBA	70.9 dBA	3.1 dBA	-12.4 dBA
50ft/5ft	75.1 dBA	83.1 dBA	-8.0 dBA	74.1 dBA	70.9 dBA	3.2 dBA	-11.3 dBA
100ft/5ft	72.8 dBA	76.7 dBA	-3.9 dBA	71.8 dBA	65.6 dBA	6.2 dBA	-10.1 dBA
250ft/5ft	68.0 dBA	68.9 dBA	-0.9 dBA	66.9 dBA	59.7 dBA	7.2 dBA	-8.1 dBA

Site 3E

Position	Pre-Overlay (Averaged)			Post-Overlay (Averaged)			Noise Reduction
	Modeled	Measured	Difference	Modeled	Measured	Difference	
50ft/12ft	80.2 dBA	84.2 dBA	-4.0 dBA	79.8 dBA	74.9 dBA	5.0 dBA	-9.0 dBA
50ft/5ft	79.9 dBA	81.6 dBA	-1.7 dBA	79.8 dBA	73.2 dBA	6.6 dBA	-8.3 dBA
100ft/5ft	76.9 dBA	78.6 dBA	-1.7 dBA	76.8 dBA	69.8 dBA	7.0 dBA	-8.7 dBA

Initial Noise Reductions

Site 3

Range of Noise Reductions	-4.4 dBA to -12.4 dBA
Average Noise Reduction	8.3 dBA

Initial Noise Reductions

Site 1

Range of Noise Reductions	-4.1 dBA to -13.2 dBA
Average Noise Reduction	8.3 dBA

Site 2

Range of Noise Reductions	+1.3 dBA to –12.3 dBA
Average Noise Reduction	5.3 dBA

Site 3

Range of Noise Reductions	-4.4 dBA to -12.4 dBA
Average Noise Reduction	8.3 dBA

Benefits of ARFC Overlay

Resists rutting, resists reflective cracking

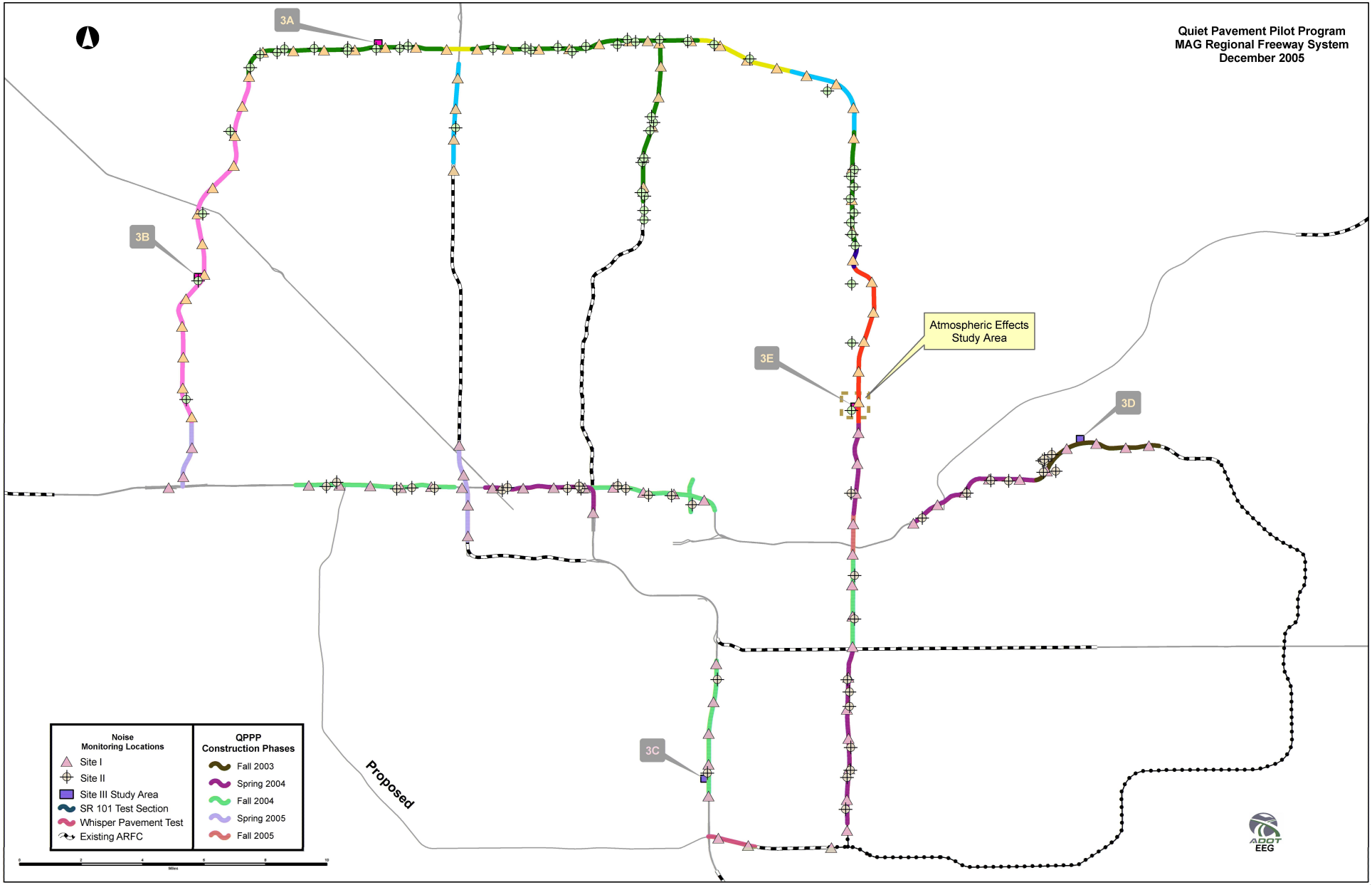
Provides a smooth, skid resistant surface

Public perception: ARFC significantly reduces noise

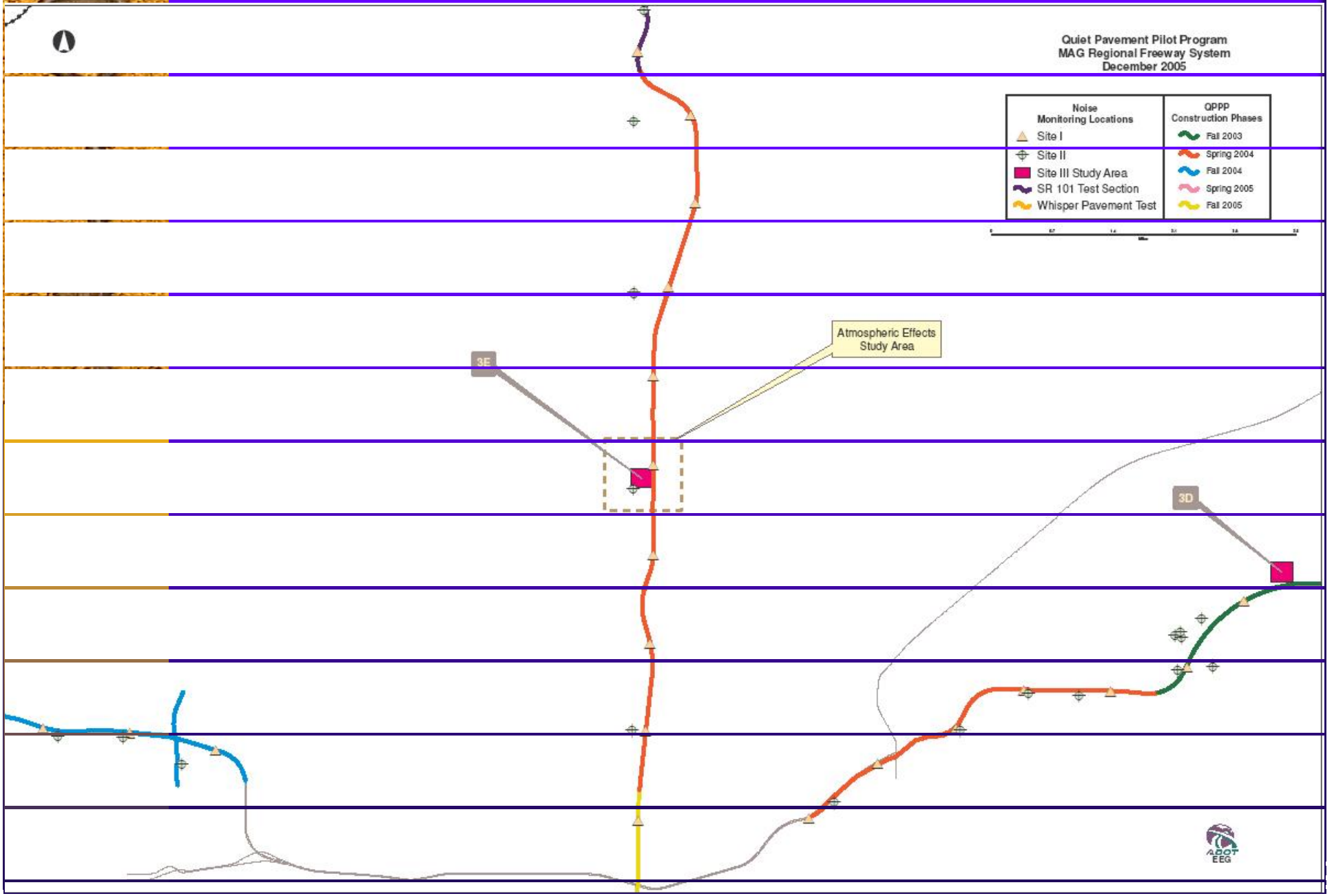
Based on initial QPPP results, ARFC overlays reduce noise in adjacent neighborhoods by about 5 dBA

ARFC overlay extends noise reduction benefits to more receivers and affects larger areas, when compared to noise barriers

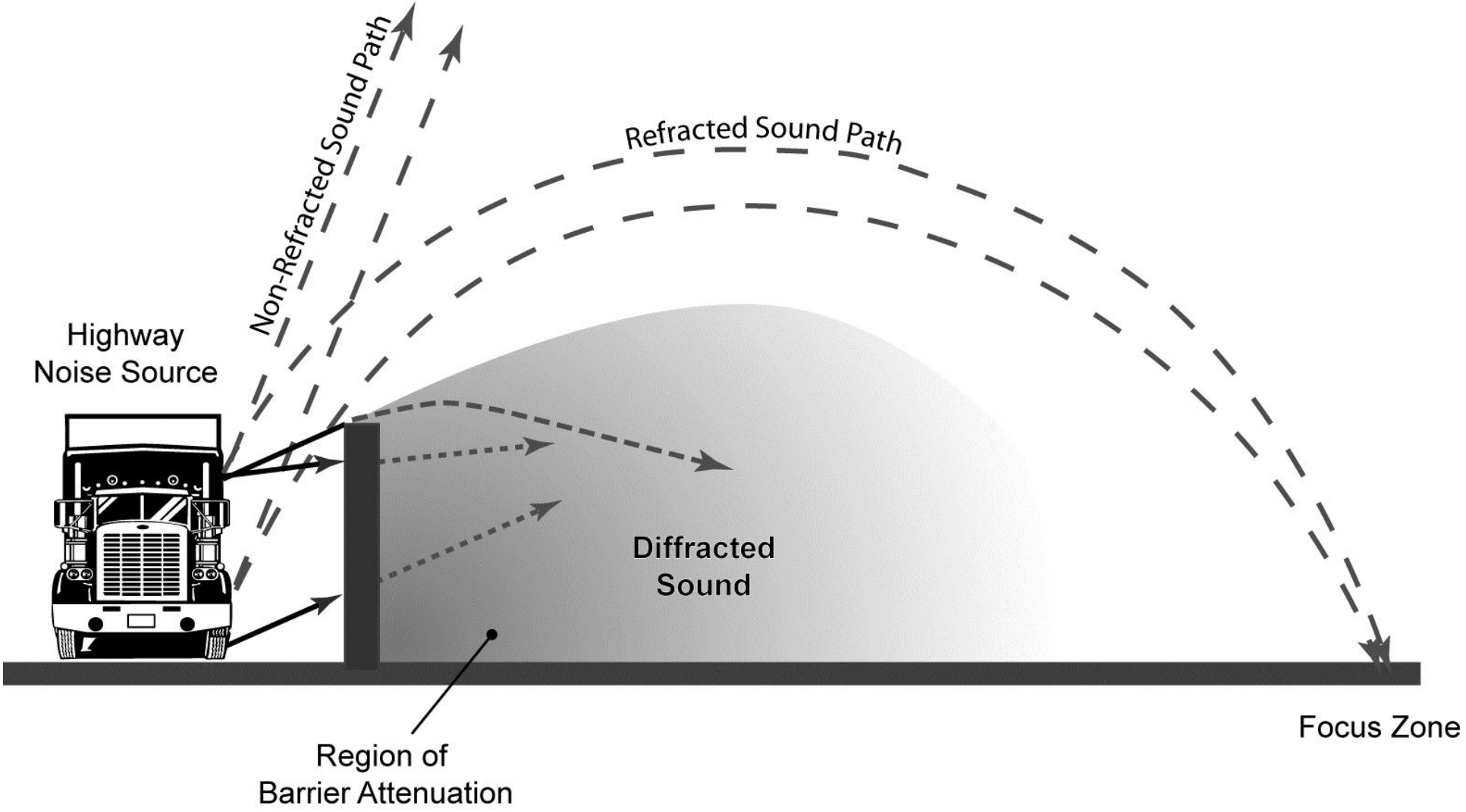
Atmospheric Effects Study Area



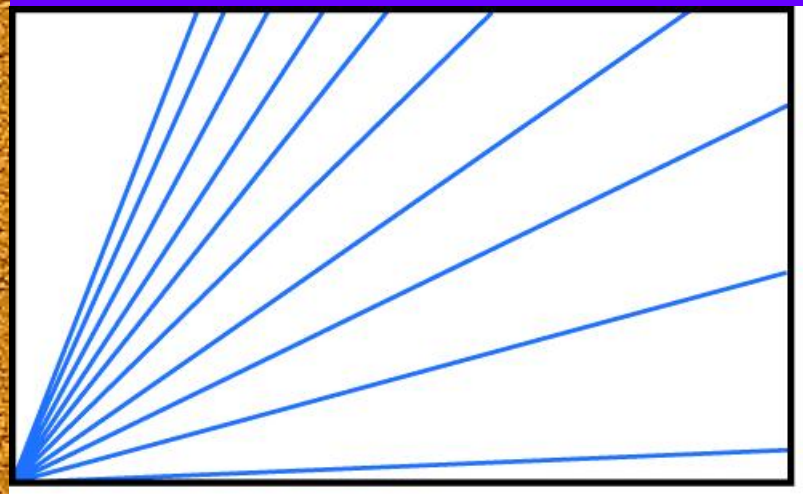
Atmospheric Effects Study Area



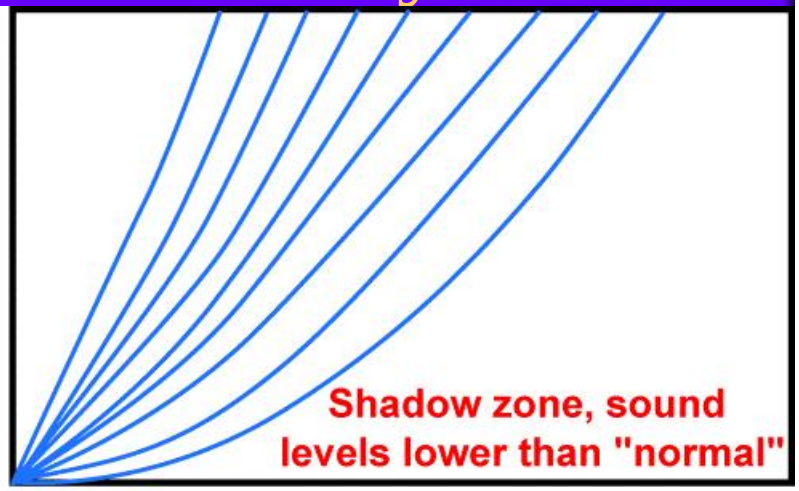
Highway Noise Source



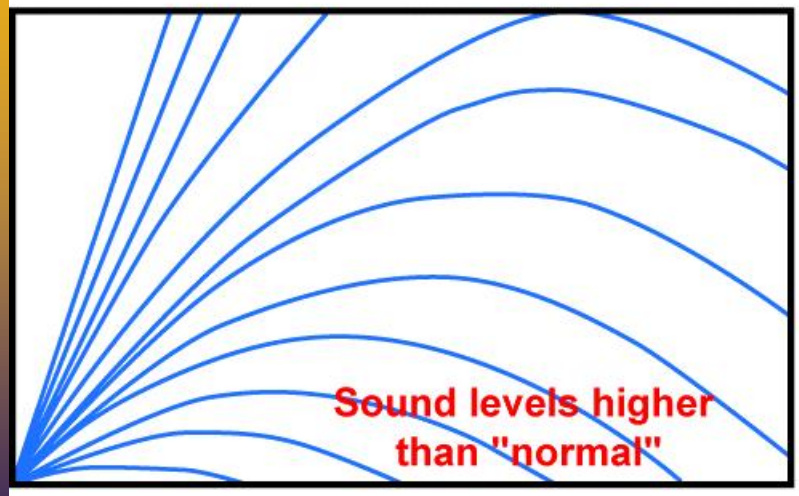
Idealized Noise Pathways



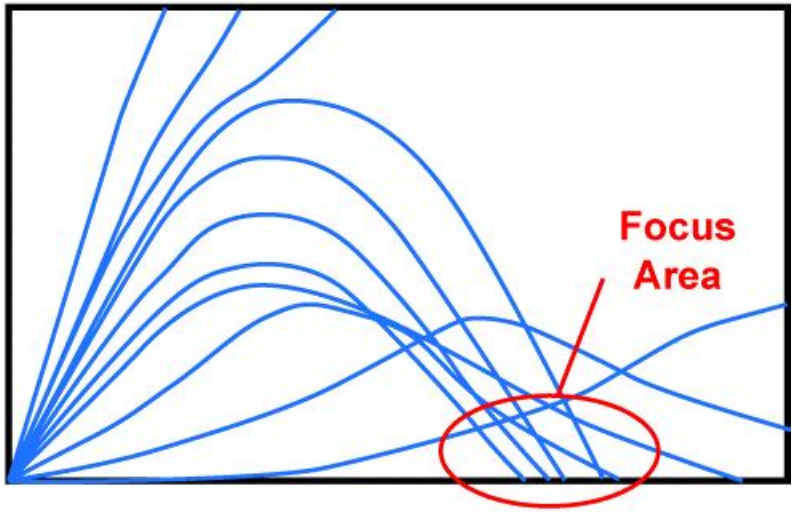
(**A**) Straight ray paths under neutral atmospheric conditions



(**B**) Upward refraction when vertical velocity gradient is negative



(**C**) Downward refraction when vertical velocity gradient is positive

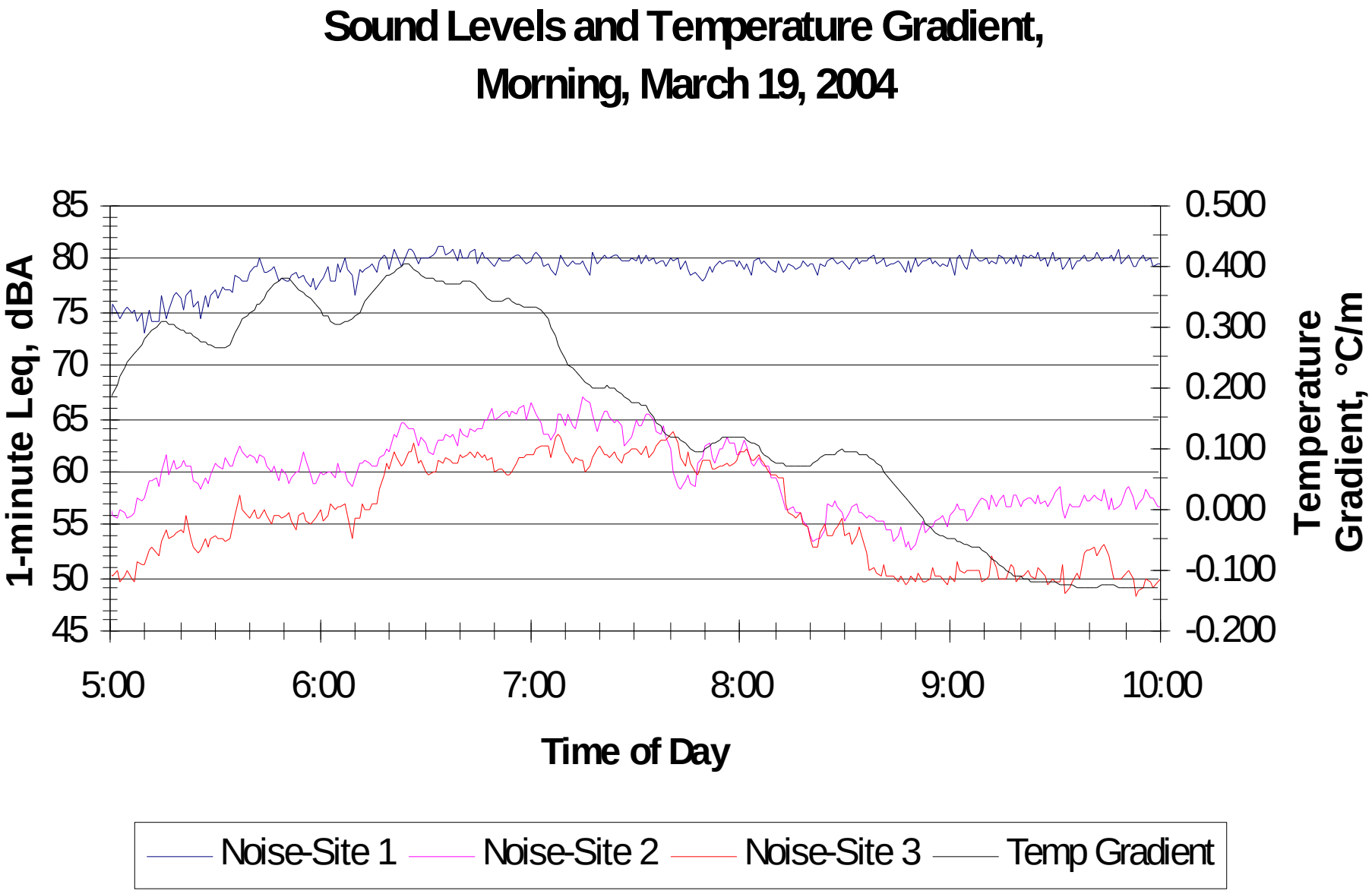


(**D**) Focusing with complex vertical velocity gradient

Noise Measurement Positions

Offset From Edge Of Freeway		
Site 1	Phase 1	100 ft
Site 2	Phase 1	1720 ft
Site 2	Phase 2	1680 ft
Site 2B	Phase 2	1475 ft
Site 2C	Phase 2	1415 ft
Site 3	Phase 1	2620 ft
Site 3B	Phase 2	2475 ft
Site 4	Phase 1	1485 ft
Site 4B	Phase 2	1485 ft

Findings of Atmospheric Effects Study



In The Future

Analyze variability in Site 2 noise reductions

Complete biannual noise measurements at Site 1 and Site 2 measurement positions

Contact Information

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EEG Website: www.azdot.gov/Highways/EEG

QPPP Website: www.quietroads.com

Questions?